

pendent corroboration, by an acute naturalist, of the importance of the groups in question; but it will be obvious that, if we follow the rules of priority, the names of Owen must be adopted; and even if we feel obliged to accept more characteristic names (those based on intestinal characters), Bronn's excellently chosen ones had already long existed, and there is no obvious reason why they (if any should supersede Owen's) should not be adopted.

Smithsonian Institution,
July 28, 1873.

XXVII.—*Notes on the Siliceous Spicules of Sponges, and on their Division into Types.* By Dr. J. E. GRAY, F.R.S. &c.

THE existence of spicules was mentioned by Ray, Ellis, and others; but I believe that Savigny was the first zoologist who exhibited them *in situ* in living sponges, in Napoleon's great work on Egypt—though, like many of the plates drawn by Savigny in that work of imperial ostentation, confined to the libraries of the few, the figures were without text, as the object for which the Emperor had undertaken the work was past. These figures have been greatly overlooked by zoologists, and the importance of the spicules in the determination of species and genera has only been more recently recognized.

Savigny, in the plates of the work above-mentioned, which he executed in 1805 to 1812, letters his plates "*Eponges charnues*," "*Eponges à piquans*," and "*Eponges à réseau*," and gives admirable figures of the spicules forming the second division, and of the horny skeletons of his "*Eponges à réseau*." The figures of the sponges are superior to any thing that has been done since. These groups were afterwards regarded as genera:—1. *Halisarca*; 2. *Halichondria*; 3. *Spongia*.

Prof. Ehrenberg names the spicules of these sponges as if he were describing a perfect animal or the shell of a mollusk, and gives to each kind of spicule a generic and specific name! overlooking the fact that there are several forms (and therefore what he considers different genera and species) of spicules in the same species of sponge.

Dr. Bowerbank, in his paper in the 'Philosophical Transactions,' which was reprinted and forms the first part of his work on British Sponges, figures a number of the different forms which these spicules assume, and names them, but in an irregular manner; and some of the names are of extraordinary length and composition. He gives different names to

spicules which are only modifications or more or less imperfect developments of the same spicule.

The spicules are divided by Dr. Bowerbank into classes according to the uses to which he believes them to be applied, and the positions which he says they occupy in the sponge; but as Dr. Bowerbank had no preliminary study of anatomy, many of his ideas are most crude and not consistent with physiological knowledge.

I am not aware of any attempt to divide the spicules into regular types; but Dr. Oscar Schmidt, in his work on Atlantic Sponges, proposes to divide the Sponges into four great divisions or orders, to which, however, he does not as yet give definite names, thus:—

I. Spicules of sexradiate type: *Hexactinellidae* and (extinct) *Ventriculitidae*.

II. Spicules anchor-shaped or of pyramidal type: *Lithistidae*, *Ancorinidae*, *Gcodinidae*, and (extinct) *Vermiculate*.

III. Spicules monaxial, polyaxial, or wanting: *Halisarcinæ*, *Gummineæ*, *Ceraospongiæ*, *Chalinæ*, *Chalinopsidæ*, *Renierinæ*, *Suberitidae*, *Desmacidinae*.

IV. Spicules calcareous: *Calcispongiæ*.

I do not understand what spicules Dr. Schmidt means by mono- and which by polyaxial.

The siliceous spicules of Sponges are divisible into a few types; and it has often occurred to me that it would greatly simplify the determination and the description and figuring of the species and genera of sponges if the spicules were arranged in series, showing the forms and modifications in which the different types present themselves to our notice. If this were done after study of the subject and with consideration, it would only be necessary in describing a sponge to mention the kind of spicule that occurs in it, instead of figuring the same modification of spicule over again every time that it occurs in any species of sponge.

I have made such a systematic distribution of the spicules in my own mind. As I am unable, from my bodily infirmities, to draw them myself or use the microscope, I have tried to induce several persons who do draw spicules and use the microscope to carry out the idea, and have even offered to pay the expense of drawing and lithographing four or five octavo plates, which I believe would be sufficient to show all the chief forms under which spicules occur, and how the spicules of each type vary by abortion, position in the different parts of the sponge, and by accidental circumstances. I have hitherto failed in having the plan carried out (though more than one person has undertaken to do it), and therefore

think it better to write a short essay on the subject, referring to the figures that are at present accessible in the works of Bowerbank, Schultze, Oscar Schmidt, Carter, and others.

The spicules are sometimes entirely absent in some horny fibrous sponges; and at others there are only a few, sunk in the substance or in the fibres; but these become gradually more abundant until the sponge seems formed of groups of spicules only kept together by a very small quantity of animal matter. Others are scattered on the external surface of the horny skeleton.

They are generally quite separate from one another; but in some sponges, which have been called Coralloid Sponges, the siliceous matter secreted by the animal is so abundant that it is deposited round the spicules, more or less uniting them together by a hard siliceous coat; but the spicules ought to be described in their separate state, in which they can almost always be seen through the siliceous matter by which they are agglutinated together. Such agglutinated spicules are figured in the 'British Sponges,' t. xv. f. 274, 275, 276, 277, 278, and also in Schmidt's 'Atlantic Sponges,' t. i., ii., & iii.

In observing the spicules of sponges, one should look out for the normal forms, and carefully abstain from being misled in the description of the species by the observation of the undeveloped or irregular forms which they sometimes assume, though it may be very interesting to trace these accidental forms to the usual state of the spicule. Dr. Oscar Schmidt, in his work on the Sponges of the Adriatic and Algiers, seems to delight in figuring the abnormal forms and the agglutinated spicules, instead of the regular typical forms which give the real characters of the species.

The siliceous spicules may be divided into several types:—

1. *Needle-like*, subcylindrical spicules, sometimes tubercular.
2. *Hamate* spicules, which are unilateral, curved at each end, subcylindrical, or more or less expanded.
3. *Quinqueradiate* spicules, which have three rays diverging from a central point, from the sides of the more or less elongated axis.
4. *Sesquiradiate* spicules, with four equidistant rays diverging from a central point from the sides of the more or less elongated axis.
5. *Multiradiate* or stellate spicules, with five or more rays arising and diverging from a common centre.
6. *Spicular spherules*, formed of a multitude of needle-like spicules diverging from a centre, forming a solid globular or oblong mass, with an areolated surface.

7. *Birotulate* spicules, consisting of a cylindrical axis, which is furnished with a more or less circular disk at each end.

1. The *needle-like, simple, subcylindrical* spicule is the most usual, and is present in its various modifications in almost every spiculiferous sponge, very often by itself, but at other times in combination with one or more of the other kinds of spicules.

The spicules are generally cylindrical, slender, and elongate; but they are sometimes short and thick.

They generally become thinner at one end, like a needle (British Sponges, t. i. f. 8); but they often taper at both ends, as in 'British Sponges,' t. i. f. 1, 2, 3.

Some spicules are like a pin and have a more or less distinct rounded head at one end (B. S. t. i. f. 23, 24, 25, 26). Sometimes instead of one head they have several globular projections (B. S. t. x. f. 228 to 233).

Some are swollen at each end or biclavate (B. S. t. i. f. 18, 19, 20, & 27).

In general the spicules are smooth; but they are sometimes partially or entirely covered with small asperities (B. S. t. i. f. 28-30, 32, 33, t. iv. f. 90, 91, 93, t. ix. f. 204-207).

The surface of the simple spicules is often more or less tubercular or spinulose in part or over the whole surface (B. S. t. i. f. 28-32).

Sometimes the spines on the spicules are placed in whorls (B. S. t. i. f. 33, t. iii. f. 67, 68, t. x. f. 238).

Sometimes the tubercles form conical elongate spines (t. i. f. 35, t. iii. f. 72).

Sometimes these spines, instead of being scattered, are placed in whorls or transverse circular lines (B. S. t. i. f. 33, t. iii. f. 66-68, 70, t. x. f. 238, 239, t. xi. f. 244-246, t. xvii. f. 289-291, t. xviii. f. 296).

Sometimes the tubercles on the surface are very long and spinose; but these may belong to another form (B. S. t. ii. f. 41, t. iii. f. 69).

The simple, fusiform or cylindrical spicule sometimes has a subcentral belt (B. S. t. i. f. 4, t. iv. f. 95); but this must not be confounded with the very much dwindled simple form of the sexradiate spine (B. S. t. iii. f. 65), which has the central thickened belt marked with four internal radiating canals.

2. The *hamate spicules* are characterized by being unilateral, and having most generally three, but sometimes only one well-developed recurved hook at each end of the spicule; but those that are attached (and they sometimes form groups and are fixed to the harder parts of the sponge) have the end

by which they are attached more or less distorted, and have the parts well developed which are at the free extremity, like those free in the sarcode. Dr. Bowerbank calls the free form "equianchorate," and the attached spicule "inequianchorate." They are very abundant in their most perfect form; they occur free in the flesh of the sponges.

The most perfectly developed spicule of this form has three well-developed spreading lobes at each end, all on the same side.

The stem between the lobes is cylindrical, more or less arched (B. S. t. vi. f. 140, "tridentate equianchorate spicule," and t. vi. f. 141-149) &c.

Sometimes the part of the stem between the hooks is dilated on the sides, as in B. S. t. vi. f. 150. For the attached or inequianchorate spicules of this form see B. S. t. vi. f. 135-137, 142, 146, 148.

Sometimes the end of the spicule is more or less expanded, and only the central lobe or spine is developed: B. S. t. vi. f. 138, with the central stem rather elongate and the expansion half-ovate; B. S. t. vi. f. 139, with the expanded ends half-oblong and the intermediate slenderer portion comparatively short.

Sometimes the spicule is very slender and only recurved at the end, as in B. S. t. vi. f. 144, 145. Indeed one would not believe that they belonged to this series; but in B. S. fig. 145 there is a slight dilatation on each side below the hook, and fig. 146 is intermediate in form between them and the more typical hamate spicule. See Carter, Ann. & Mag. N. H. 1871, viii. t. iv. f. 8; 1872, ix. t. x. f. 5.

Many of the spicules of this series are not so perfectly developed, being much more simple, subcylindrical, unilateral, with recurved ends. In one, the ends are longer, recurved, sharp-edged on the inner side (see B. S. t. v. f. 112, "trenchant contort bihamate").

Others are cylindrical in the body; and Bowerbank calls them "simple hamate spicules" (B. S. t. v. f. 109, 114). These spicules sometimes have the terminal hooks turned in opposite directions, forming an S, thus losing their unilateral character; but this is only a malformation (B. S. t. v. f. 110, 111). They have a close resemblance to the least-developed bihamate spicule, figured in B. S. t. vi. f. 144, referred to above, showing the passage of the two forms of spicule into one another. Some of these more slender spicules have a prominence or knob on the middle of the inner side of the body (B. S. t. v. f. 116), some on the middle of the outer side (B. S. t. v. f. 115), and some on both the inner and outer sides (B. S.

t. v. f. 117). Some of these unilateral spicules, instead of having a hook, have a broad rounded disk at each end. Bowerbank shows, by a series of figures of a spicule of this kind, which he calls "bipocillated bihamate," from *Halichondria Hyndmani* (B. S. t. v. f. 123-127), the various forms which the spicule assumes before it is fully developed, and the various states in which it is to be seen in the same sponge; and the biclavate and bihamate spicules (B. S. t. v. f. 118-120) appear to belong to the same series.

The spicules which Bowerbank calls inequitrirotulate and eccentric trirotulate (B. S. t. x. f. 131-134) are evidently allied to those last described and t. v. f. 118-120.

That these spicules are variations of the same spicule I think is proved by their occurring mixed together in the same sponge, and generally in conjunction with the bihamate spicules (see Schmidt, Spongienf. t. v. f. 2, 3, 5, 6, 7, all different species of *Esperiadæ*); indeed they may be undeveloped or rudimentary hamate spicules.

The "tricurvato-acerate" spicule (figured by Dr. Bowerbank, B. S. t. iv. f. 96-98, where the spicule is slightly sinuous and the end only recurved in the most perfectly developed spicule, f. 96), appears to belong to this type, or to be intermediate between it and the simple needle-like spicule.

3. The *quinqeradiata* or "trifurcate" spicules are distinguished by always having only three equidistant lateral rays from the sides of the more or less elongated axis.

They do not very generally occur in a perfect state of development, with an elongate axis having three equidistant rays coming from the middle of its length; but they are sometimes found in this state mixed with the more usual form, where the upper part of the axis is very short or absent, and the rays are very generally recurved (see B. S. t. ii. f. 58, where the spines are directed towards the shorter end; t. ii. f. 55, 56, where the spines are directed from the shorter end of the axis, which is bent outwards).

Bowerbank calls the first spicule (fig. 58) "spiculated porrecto-ternate," and f. 55, 56, 57 "spiculated recurvo-ternate," keeping the term "recurvo-ternate" for the spicules in which one part of the axis is entirely absent (f. 54).

Most generally the axis does not reach beyond the rays, as in the last referred to; and the lateral rays are generally short and recurved, as in B. S. t. ii. f. 48, 54, t. iv. f. 81 & 82; but the rays are sometimes directed forwards (t. iv. f. 77-80, t. v. f. 128, 129), and they are often expanded horizontally (t. ii. f. 45, 47, t. iv. f. 95). Of course, all these spicules have different names, though you may find them combined in the same specimen.

Schmidt figures several spicules of this form (t. iii. f. 28, 29, t. iv. f. 2, 7, &c.), and Bowerbank (P. Z. S. 1872, t. v. f. x. & xi., t. xlv. & xlvii.; 1873, t. i.-iii. & vii.

Sometimes one of the lateral rays (B. S. t. ii. f. 48), more frequently all, especially when expanded, are forked at the end (t. ii. f. 50, 51, called "furcated attenuato-patento-ternate spicules," and t. v. f. 130, where they are called "bifurcated expando-ternate"). The difference between the two spicules figured is that in f. 50 & 51 the rays are expanded horizontally, and in f. 130 they are directed rather backwards from the axis.

Schmidt figures this kind of spicule at t. iv. f. 5; but he also figures (Suppl. t. iii. f. 3), with the forks well defined, spicules with only short recurved rays—one, two, or three of the rays being bifid at the end—showing how these forms pass into one another, even in the same sponge.

Bowerbank figures (t. xxxi. f. 362) a portion of *Tethea cranium*, in which he shows the exceeding difference of form of the spicules of this group which are found in a single fragment of a single species. If carefully examined, in it will be found almost all the forms of trifurcate spicule with simple rays I have noticed above, including those with the central axis produced beyond the rays, the rays bent from or recurved towards the axis of the same small slice of a sponge.

The "verticillately spined" triradiate spicule (B. S. t. iv. f. 84, t. x. f. 235, 236) appears to belong to this type, with its axis reduced to a minimum on each side.

The *quinqueradiate spicules* generally have an elongated axis compared with their lateral rays; but in one modification the axis is not produced on the outer side, and is very short and rudimentary on the other side; and the bifurcate rays are very broad and spreading, like the bifurcate rays of the more typical spicules of the series (B. S. t. ii. f. 52, the irregular furcated patento-ternate spicules, and t. ii. f. 53, which has the axis slightly developed on both sides of the rays). Spicules of this form have sometimes on one side a very short axis, and a broad, expanded, terminal disk, which is sometimes orbicular, nearly entire, and at others crenated or divided into lobes on the edge. When lobed it is usually divided into three greater portions, which are lobed on their surface; but whatever may be the form of the disk, they are always marked with three short lines diverging from the central spot, and sometimes forked at the end (B. S. t. iv. f. 102, 103, t. v. f. 104-108), and are called "foliato-peltate." Carter, Ann. & Mag. N. H. 1871, vii. t. vii. & viii. These spicules occur in the different species of Coralloid or Lithistidine sponges, and show the existence of quinquerradiate spicules in that family, as the spherules which are character-

istic of *Tethyadæ* are sometimes found with well-developed quinquerradiate spicules (see Schmidt, Suppl. t. iii. f. 8).

Mr. Carter figures a beautiful modification of this spicule found in *Corticium abyssi*, which has branches at the ends of the lateral rays. The lower end of the axis and the lateral rays are crenated on the sides (see Ann. & Mag. Nat. Hist. 1873, xii. t. i. f. 3-6).

Dr. Bowerbank, in his representation of the spines of the very young *Tethya cranium*, represents the long clasping spicules as having only one hook, on one side, at the end (B. S. t. xxv. f. 343). Mr. Carter has well observed that this is a "monstrous representation" (Ann. & Mag. Nat. Hist. 1872, ix. p. 420, t. 20); and at p. 430 (t. xxii. f. 16) he gives four representations showing how the one-armed spicule gradually develops into a three-rayed one, and (f. 17) the variations of shape that occur, and that the spicules belong to the quinquerradiate form, and (in t. xxii. f. 3) how the axis is sometimes produced beyond the lateral spicules.

Bowerbank (B. S. t. ii. f. 41 & 42) figures a curious spicule, which appears to have three diverging trifid rays on each end of a very short broad axis, and may be a reduplication of this. Indeed B. S. fig. 197 may also be something of the same kind, but with a shorter axis; probably B. S. fig. 69 may be a series of branched rays arising from a cylindrical axis. B. S. figs. 199 & 200 may be modifications, of the same kind, of double series of three simple or branched rays arising from two centres of the axis; but these modifications have not occurred to me.

4. The *sextirradiate spicules* form a large group. They consist essentially, in the most simple and perfect state, of an elongated axis giving out from the centre of its length four equidistant arms diverging at right angles from the axis, as in B. S. t. vii. f. 184, 185.

The various modifications of this spicule have been well shown by Schultze in his essay on *Hyalonema*, t. iii. & iv.

Bowerbank figures several variations in B. S. t. vii. f. 184-195, as they occur in different parts of *Alcyoncellum*. Sometimes 1, 2, 3, or all the lateral arms are wanting; in others, as fig. 183, the four lateral arms are complete, and one arm of the axis is wanting; but Bowerbank gives to each of these spicules a different name.

The *sextirradiate spicules* are abundant and of the usual form in *Carteria*, the sponge that grows parasitic on the top of the glassrope (*Hyalonema*) from Japan; but when this sponge occurs, as it sometimes does, under the bark of the *Hyalonema*, then the spicules seem to change their character. Instead of

the axis and arms being long, slender, and subulate, they are short, thick, and truncated at the end, and are more or less covered with spicules (see Schultze, *Hyalonema*, t. iii. f. 14, 15). Dr. Bowerbank gives five figures of the spicules (all in a more or less imperfect state) of the sponge from this situation. He does not figure one in its perfect state, with all the six arms developed; but he figures one with one end of the axis wanting and the rest present (B. S. t. vi. f. 157). Then he figures other cross-shaped spicules with both ends of the axis wanting (B. S. t. vi. f. 154-156), and one in which the unbranched axis alone is developed (B. S. t. vi. f. 153).

O. Schmidt figures several modifications and adhesions of spicules of this type in his 'Spongienf.' t. i. & ii., showing many peculiarities.

When all the lateral arms in this kind of spicule are wanting, the axis, which is simple and needle-like, is known from the simple spicule by having a well-marked cross in the minute belt in the centre of the spicule (B. S. fig. 65).

Schmidt figures a spicule of this type in which the axis and lateral arms are of equal length, all tapering and acute, and with irregular spines on the side (Spongienf. t. i. f. 5), so that it might almost be taken for a stellate spicule.

When the sexradiate spicules are placed on the surface of the sponge, as they often are, forming a kind of armour to it, with the inner axes of the spicules diverging from the centre and the lateral arms forming the outer surface of the sponge, the outer part of the axis (which would otherwise project beyond the sponge) is more or less completely wanting. This form of spicule is called "*the nail-like spicule*" (see Schultze, *Hyalonema*, t. iv. f. 5-9). See Carter, *Ann. & Mag. Nat. Hist.* 1869, iv. t. i. & ii.; 1871, vii. t. x. & xvii.; 1872, ix. t. x., t. xxi. & xxii.; 1872, ix. t. xx.

When these sexradiate spicules arise from the outer surface at the base of a sponge, and are used as anchors to keep the free sponge in its place, the axes of the spicules are often very long and hair-like, and have four short, recurved, broad rays at the end, the axis not extending beyond the rays (B. S. t. iii. f. 59). Bowerbank calls these "apically spined recurvo-quaternate prehensile spicula." Probably the spicule figured in B. S. t. iii. f. 73-76 as "spinulo-recurvo-quaternate spicula" is also a sexradiate spicule; but I have not seen it. The spicule figured B. S. t. xviii. f. 292 also belongs to this modification of the sexradiate spicule. These spicules are not to be confounded with the "fusiformi-recurvo-ternate spicula" (B. S. t. iv. f. 81, 82) with three terminal rays, which evidently belong to the quinquerradiate spicula. Mr. Carter

has shown the change of form in the elongated clasping basal or rooting spicules of this group in *Rossella*, where the spicules often have, as well as the four recurved lateral rays (*l. c.* (t. xxi. f. 2), the shaft produced beyond the lateral rays, as in t. xxi. f. 1, 3.

In some, especially of the superficial sexradiate spicules, the arms of the different spicules are placed so that the arms of the neighbouring spicules are parallel to each other; but in some sponges they are oblique, compared with the axis of the sponge, and in others they are perpendicular and transverse to the axis of the sponge, producing rhomboidal or rectangular areolæ on its surface, which are especially visible when the arms of the neighbouring ones, which form the square areolæ, coalesce and form a solid network, as in the genus *Farrea* (B. S. t. xv. f. 277, t. xxi. f. 311, which represents a part from the interior of a sponge which has the axis of the spicules developed at both ends).

Most of the spicules of this division are smooth; but Dr. Schultze figures several varieties of forms which have the arms more or less tuberculated (*Hyalonema*, t. iii., t. iv. f. 6), and others, which are scattered, with elongated acute spines directed from the centre (*Hyalonema*, t. iv. f. 2, 4, 7, 8, 9, all being figured from one sponge, and showing the folly of naming spicules in Dr. Bowerbank's way).

The elongate tapering rays of the spicules of this form are sometimes furnished with a branch on each side not far from the base (B. S. t. viii. f. 188, 189), which form a passage to the more stellate spicules of this group (see B. S. t. viii. f. 188, "bifurcated rectangulated hexaradiate stellate spicules," and t. viii. f. 189, "trifurcated attenuato-hexaradiate spicules"). These spicules show the passage between the long-armed forms and the short divided-rayed ones which follow.

Many sexradiate spicules, instead of having long, conical, tapering, acute axes and rays, have all the rays short and of equal length, sometimes terminating in a kind of cup (B. S. t. viii. f. 196, "pocillated hexaradiate stellate spicule"), or in a broad expansion deeply divided into lobes (B. S. t. viii. f. 195, called "coronato-hexaradiate stellate spicule"). In others each ray of the spicule ends in a cluster of four or more elongate linear arms, ending in a tubercle (B. S. t. viii. f. 190-192). They are called spinulo-trifurcated, spinulo-quadrifurcated, and spinulo-multifurcated hexaradiate stellate spicules. In others the rays terminate, like the former, in a group of linear arms; but they assume a bell-shape, and each lobe is dentated and reflexed at the end (B. S. t. viii. f. 193, 194), and are called floricommo-hexaradiate spicules.

In *Carteria* there is a very extraordinary form of the sex-radiate spicule, which, in its perfect state, has six short arms of nearly equal length, each arm ending in a series of four or eight elongate oblong reflexed radiating lobes. Dr. Bowerbank only represents this form of spicule, which he calls "multi-dentate birotulate spicule" (B. S. t. iii. f. 62), as simple with the lobes at each end; and Dr. Schultze (*Hyalonema*, t. iv. f. 11, 12) has figured the same rudimentary spicule; but Mr. Carter has found it perfectly developed into six rays, and different specimens with the lateral rays more or less perfectly developed, some with terminal radiating lobes, and others with the arms reduced to mere conical processes, as may be seen in Dr. Schultze's figure.

Schultze, in his '*Hyalonema*,' figures a minute spicule having four short recurved conical arms at each end (t. iv. f. 10); and Bowerbank (B. S. t. v. f. 122) figures this spicule, which he says is "dispersed in considerable abundance in the interstitial membrane" of *Carteria*, and calls it "quadrihamate spicule;" but this spicule, I suspect, from the spinules on its stem, is very probably only an imperfect state of a sexradiate spicule, like the one which Bowerbank calls "birotulate," having only four lobes instead of many.

Mr. Carter figures a very minute birotulate spicule of this kind occurring in *Corticium abyssi* (Ann. & Mag. Nat. Hist. 1873, xii. t. i. f. 7). In *Echinospora* there is a solid octahedral spicule, each of the six angles produced into a cylindrical ray dentated at the end; this is found with two flat three-rayed stars placed one on the other, figured in the '*B. Sponges*,' t. x. f. 197 (see Ann. & Mag. Nat. Hist. 1870, vi. pp. 272 & 340). Dr. O. Schmidt, in his '*Atlantic Sponges*,' t. ii. f. 16, figures a hollow octahedral formed by marginal tubes, and having six diverging rays.

5. The *multiradiate* or *stellate spicules* have five or more rays, arising and diverging from a common centre or very short axis, as the stellate spicules figured by Bowerbank (B. S. t. vi. f. 158-161) found along with the spherules in *Pachymatisma* and *Tethea*. (See also Bowerbank, P. Z. S. 1872, t. xlv. - xlviii., and 1873, t. i. - iii. Schmidt, '*Sponges*,' t. iii. f. 22, 26, t. iv. f. 1, 2, 4, t. v. f. 1; '*Algiers*,' t. iii. f. 2, 4, t. iv. f. 5, 6, 8, Suppl. t. v. f. 5. Carter, Ann. & Mag. Nat. Hist. 1867, iv. t. i. & ii.)

Probably the candelabrum-like spicule (Schmidt, *Spongienf.* t. iii. f. 25) should also belong to this series.

There are very probably many more forms to be referred to this type; but all this will require much more study than I am able to bestow upon the subject. (See B. S. t. vi. f. 164, 165,

the "sphero-stellate with conical points," and f. 166, with "cylindro-subfoliate rays.")

It is doubtful if some of these stellate specimens are not produced by some of the layers being placed upon one another; but this must be left for further study, as also such elongate spicules with diverging spines as B. S. t. i. f. 35, and the "elongato-attenuated" spicule, t. iii. f. 72.

Mr. Carter figures beautiful forms of this spicule as occurring in *Chondrilla australiensis*, and calls them *sphero-stellate* and *radio-stellate* (Ann. & Mag. Nat. Hist. 1873, xii. t. i. f. 16).

6. The *spicular spherules* differ from the isolated spicules before described by being formed of a multitude of parallel needle-like or clavate spicules diverging from a central point, and forming a solid globular or oblong mass with an areolated surface.

These spherules sometimes form the greater part of the sponge, and at other times are found in conjunction with quinqueradiate or trifurcate spicules. (See B. S. t. xxiii. f. 326-328, t. xxiv. f. 329-334, t. xxvii. f. 353, t. xxviii. f. 354; P. Z. S. 1872, t. x. & xi., and 1873, t. i. f. 6; Schmidt, Spongienf. t. iv. f. 4.) Dr. Bowerbank, who compares the anatomy of sponges to the anatomy of man, calls this mass of spicules an "ovarium"—as he does the spicules of the sponge, of which he observes that "those of *Farrea* have a very close approximation to the tubular form of the bones of the higher animals." The spherules certainly do not contain any eggs, and are not even allied to the spore-cases of *Spongilla*: the tubes of the latter are produced by the absorption of the spicule which the fibres originally enveloped.

7. The *birotulate* spicules in their most perfect state of development consist of cylindrical axes with an expanded more or less circular disk at each end. They are almost exclusively found in the substance of the case which surrounds the spore, or, as Bowerbank calls it, the "ovary" of freshwater sponges (*Spongilla*). Bowerbank figures several (B. S. t. ix. f. 210-227). Sometimes the disks are very small, and the axis very long (f. 210, 211); and sometimes the axis is very short and the disk very large (f. 213). Sometimes one of the disks is partially and at others almost entirely wanting (f. 223, 224); and at others there is only a single circular disk, with the axis reduced to a small central prominence (B. S. f. 225, 227). In the two latter cases they have other names, being called "boletiform slender" and "umbonate scutulate." The axes in several of these spicules are more or less spinulose.

It is very easy to arrange the sponges which have only one of these types of spicules in company with simple unbranched

spicules ; but it is much more difficult with those sponges where two or even more types of spicules are found in connexion with the usual simple ones (in fact, having the characteristics of more than one group)—as, for example, in the coral-
loid sponges, where we have the sexradiate spicules well developed in conjunction with the more or less discoidal spicules, which have a resemblance to the trifurcate spicules, typical of another group.

In the same way it is not uncommon to find the spicular spherules (which are spherical masses of spicules so characteristic of *Geodia*) in conjunction with quinquerradiate spicules (which are characteristic of a different group) ; and hamate spicules, which are frequently only found in conjunction with simple unbranched spicules, are also found with quinquerradiate spicules, and, I believe, rarely with sexradiate spicules.

These facts only go to prove that there are in reality no very broadly marked groups, especially of a secondary degree, in Nature, and that there are a number of intermediate forms which are to be arranged along with the other genera of the group to which they bear the greatest resemblance in other respects.

However, there is one evil particularly to guard against, especially with regard to hamate spicules—to make sure that they really belong to the sponge in which they are found, and are not accidentally intermixed with it from the sea and other external sources.

When the spicules of a species are figured, it is very desirable that the comparative size of the different forms of spicules should be carefully preserved, and, if any spicule is figured of a larger size than the others, that the difference of its scale should be stated. The want of attention to this point greatly detracts from the value of Dr. Schmidt's figures. I could not believe that the slides of the spicules of the different species that he had sent me were correctly named, when I compared them with his figures, until I observed that he had paid no attention to this circumstance, and that in a figure that appeared to be taken from one group of spicules in a slide, the smaller spicules were represented on a much greater scale, and therefore appeared to be larger than the greater ones.

One must not confound the siliceous spicules of sponges with the horny stars described and figured by Mr. Carter as occurring in *Aplysina corneostellata* from the coast of Spain (Ann. & Mag. Nat. Hist. 1872, x. p. 105, t. vii. f. 1), which is most probably the sponge that the Germans have described and written so much about under the name of *Darwinella* ; but these horny-fibred, six-rayed stars have no relation to

the siliceous spicules of other sponges, but seem to be modifications of the horny skeleton of the *Aplysine* and other horny sponges, as Mr. Carter considers them. They differ from spicules in their mode of development, their structure, form, and the manner in which they adhere together; indeed it would hardly occur to any one but a theorizing German to regard them as such.

The results of this paper may be thus epitomized :—

1. *Needle-like spicules.*

- a. Cylindrical.
- b. Tapering at each end.
- c. Tapering at one end.
- d. Club-shaped.
- e. With a head at one end. Sometimes this head is double or treble.
- f. With a head at each end.
- g. With a thick belt in the middle.

Each of these is straight or sinuous, has the surface smooth, tubercular, or spinulose, the tubercles or spines being sometimes scattered, at others placed in whorls.

2. *Hamate spicules.*

- a. The ends dilated and divided into three acute processes; but sometimes the lateral processes are wanting. When free in the sarcod, both ends are equally dilated; when attached in groups, the attached end is only imperfectly developed.
- b. The spicules compressed, with a sharp edge at each end.
- c. The spicule more or less cylindrical, curved at each end. These spicules are sometimes bent like an *s*, at others only slightly doubly curved or nearly straight.

3. *Quinqueradiate.*

- a. Spicules with the axis very long and the rays tapering and sometimes forked.
- b. Axis very short, the rays elongate, slender, forked, or expanded into a broad, circular or more or less lobulated disk.

Bowerbank figures some spicules which appear to belong to this division, without any axis; but I have not had the opportunity of seeing them.

4. *Sexradiate spicules*.

- a. With the rays simple, elongate, attenuated, smooth or spinulose.
- b. Rays cylindrical, blunt, rugose at the end.
- c. Rays short, thick, entirely rugose or spinulose.
- d. Rays attenuated, with side rays.
- e. Rays enlarged at the end, simple or torn.
- f. Rays divided into elongated simple branches at the end.
- g. Axis elongate, ending in short recurved rays at the end used for anchoring.
- h. Axis and rays ending in 4 or 8 recurved lobes.

5. *Multiradiate spicules*. Rays tapering or cylindrical, smooth or tubercular.

6. *Spicular spherules*. Orbicular or oblong, smooth or tubercular.

7. *Birotulate spicules*.

XXVIII.—*Note respecting the Tracheal Pouch of the Emu.*

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[AMONG other items of intelligence from my friend Dr. Coughtrey is one relative to some points in the anatomy of an Emu (*Dromæus novæ-hollandiæ*, Vieill.) examined by him. He mentions having found a hitherto unnoticed valve guarding the orifice of the right precaval vein, a detailed account of which he intends shortly to publish. As regards a probably similar structure in the ostrich (*Struthio camelus*), I have called his attention to Professor Macalister's paper on the anatomy of this bird (Proc. R. I. A. 1864, p. 541). Dr. Coughtrey's observations on the tracheal pouch I subjoin in abstract, his further minutiae forming a separate communication to the Literary and Philosophical Society of Liverpool. As his researches partially corroborate and partially differ from my own, I have thought a short notice might appropriately be inserted in the 'Annals.' Dr. Coughtrey says:]

In a specimen of this creature which I had the opportunity of dissecting on the 8th of March last I found the tracheal pouch, which is a marked character of the Emu as distinguished from other Struthious birds. The sac in question has already